CODE OF PRACTICE FOR THE SAFE OPERATION OF FOSSIL-FUEL BOILERS

Issued under Section 18A of
the Boilers and Pressure Vessels Ordinance

Occupational Safety and Health Branch
Labour Department

safety at work

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FOR THE SAFE OPERATION OF
FOSSIL-FUEL BOILERS

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Boilers and Pressure Vessels Ordinance

CONTENTS

INTRODUCTION

The Boilers and Pressure Vessels Ordinance, Cap. 56, sets out the provisions relating to the control, use and operation of boilers and pressure vessels in Hong Kong. The Commissioner for Labour has been appointed as the Boilers and Pressure Vessels Authority in accordance with section 4(1) of the Ordinance.

This Code of Practice is issued pursuant to section 18A of the Ordinance for the purpose of guidance to owners and competent persons of boilers for safe operation of fossil-fuel boilers.

This Code also provides advice on the acceptable standards in the design, manufacture, installation, maintenance, examination, testing and operation of boilers.

Where there is any conflict or inconsistency between this Code and any statutory provision, that statutory provision prevails.

Under section 18A(2) of the Ordinance, any person who fails to observe the provisions of this Code shall not render himself liable to criminal proceedings of any kind, but any such failure may, in any proceedings whether civil or criminal and including proceedings for an offence under the Boilers and Pressure Vessels Ordinance, be relied upon by any party to the proceedings as tending to establish or to negative any liability which is in question in those proceedings.

Owners and competent persons should follow the guidance of this Code and the instructions from manufacturers' of boilers as appropriate.

Enquiries

If you wish to enquire about this Code of Practice or require advice on the regulation of boilers and pressure vessels, please contact the Boilers and Pressure Vessels Division of the Labour Department through:

Telephone : 3107 3458
Fax : 2517 6853
E-mail : enquiry@labour.gov.hk

Information on the services offered by the Labour Department and on major labour legislation is also available on our website at http://www.labour.gov.hk.

For details on the services offered by the Occupational Safety and Health Council, please call 2739 9000.

Complaints

If you have any complaint about unsafe workplaces and work practice, please call the Labour Department's occupational safety and health complaint hotline at 2542 2172 or via online OSH complaint form. All complaints will be treated in the strictest confidence.

Online OSH complaint Form

LIST OF APPLICABLE ORDINANCE AND REGULATIONS

(a) Boilers and Pressure Vessels Ordinance, Cap. 56

(b) Boilers and Pressure Vessels Regulations, Cap. 56A

(c) Boilers and Pressure Vessels (Forms) Order, Cap. 56B

(d) Boilers and Pressure Vessels (Exemption) (Consolidation) Order, Cap. 56C

CHAPTER 1
GENERAL

1.1 Aims and Scope

The aim of this Code of Practice is to promote the safe operation of fossil-fuel boilers to the industry.

This Code may also offer practical guidance for those responsible for the safety and direct supervision of fossil-fuel boilers.

The scope of the Code covers basic information in relation to design, manufacture, installation, examination, test and safe operation of fossil-fuel boilers.

1.2 Interpretation

For the purpose of this Code:

"accident" means an explosion of a boiler or pressure vessel and also means any damage or other occurrence to or in a boiler or pressure vessel or any part of a boiler or pressure vessel that weakens the boiler or pressure vessel and renders it liable to explode or collapse or is calculated to weaken it and render it liable to explode or collapse;

"Authority" means the Boilers and Pressure Vessels Authority that is, the Commissioner for Labour;

"auxiliary equipment" means every pipe, fitting and attachment connected to or with a boiler or pressure vessel, as the case may be, and, in the case of a boiler, also means any fuel burning installation connected therewith;

"boiler" means any closed vessel in which for any purpose steam is generated under pressure greater than atmospheric pressure and also means any economizer used to heat water being fed into any

such vessel, any superheater used for heating steam and any fitting directly attached to such vessel that is wholly or partly under pressure when steam is shut off, and any vessel in which oil is heated at a pressure greater than atmospheric pressure;

"boiler inspector" means a person who has been appointed by the Authority to be a boiler inspector and whose appointment to be a boiler inspector has not been suspended;

"certificate of competency" means a certificate of competency issued by the Authority;

"certificate of fitness" means a certificate of fitness of a boiler/pressure vessel issued by an appointed examiner under section 33 of the Boilers and Pressure Vessels Ordinance;

"competent person" means a person whose name is for the time being entered in the register of competent persons kept pursuant to section 7(1)(e) of the Boilers and Pressures Vessels Ordinance;

"fuel burning installation" means any oil, or other liquid, or gas fuel burning installation by means of which heat is applied to a boiler for the purpose of generating steam or heating oil therein;

"Ordinance" means the Boilers and Pressure Vessels Ordinance, Cap. 56;

"owner", in relation to a boiler, includes any person who is in possession of the boiler under an agreement of hire purchase or under a contract between a supplier of the boiler, or the agent of any such supplier, and such person for the sale of the boiler, notwithstanding that the property in the boiler has not passed to such person, and, where the owner of a boiler cannot be found or ascertained or is absent from Hong Kong or is under disability, also includes the agent of the owner;

"recognized inspection body" means an independent inspection body recognized by the Boilers and Pressure Vessels Authority.

1.3 Registration of a Boiler

1.3.1 The owner of a new boiler shall, not less than 30 days before he/she intends to put the boiler into use, deliver to the Authority:-

(a) one copy of the maker's certificate and one copy of the certificate of inspection during construction issued in respect of the fossil-fuel boiler by a recognized inspection body; or

(b) documentary evidence, to the satisfaction of the Authority, that the fossil-fuel boiler complies with a recognized engineering standard or code in respect of:-

(i) the welders employed and welding procedures used in the construction and erection of and, if repairs have been carried out, in the repairs to, the fossil-fuel boiler;

(ii) heat treatment before and after welding;

(iii) tests and inspections carried out on the fossil-fuel boiler;

(iv) kind and grade of material used in the pressure parts of the fossil-fuel boiler;

(v) any other relevant technical details that the Authority may, by notice in writing, specify; or

(c) where the owner cannot deliver either the documents referred to in paragraph (a) or the documents referred to in paragraph (b), details of the design and methods of construction, inspection and testing of the fossil-fuel boiler and its auxiliary equipment.

1.3.2 All above documents must be endorsed by a boiler inspector to the effect that they relate to the equipment to be registered. The boiler inspector shall determine the maximum permissible working pressure at which the boiler may be operated and state that in the documents accompanying the application of registration. Where a document is not written in English or Chinese, it should be accompanied by an English or Chinese translation.

1.3.3 On completion of the necessary formalities described in the above paragraphs the Authority will register the fossil-fuel boiler and allot a registration number which must be engraved by the owner in a conspicuous position on the boiler.

1.4 Certificate of Competency

1.4.1 Any person who has evidence to show that he has adequate experience, skill and knowledge in the operation of fossil-fuel boilers or has passed an examination conducted by the Authority may apply to the Authority for a certificate of competency subject to payment of a prescribed fee. If the Authority is satisfied that the applicant has adequate experience, skill and knowledge in the operation of fossil-fuel boilers, it may issue a certificate of competency to the applicant.

1.4.2 Most of the accidents resulting in injury or loss of life can be avoided if the fossil-fuel boilers and their auxiliary equipment are operated properly.

1.4.3 The Ordinance requires that a competent person must be present at all times to directly supervise the operation of the fossil-fuel boiler to ensure safety in its operation. An employer should arrange for additional persons to receive the necessary training and to obtain Certificate of Competency so that such persons can stand in as a relief person during the absence of the boiler operator. In no circumstances whatsoever should a fossil-fuel boiler be operated without a competent boiler operator.

1.4.4 The competent person who operates or supervises the operation of fossil-fuel boilers must be in possession of a valid Certificate of Competency issued by the Authority. Appendix I lists the equipment which holders of different Certificates of Competency can operate.

1.5 Periodic Examination

1.5.1 All fossil-fuel boilers must be properly maintained in accordance with provisions laid down in the Ordinance and its Subsidiary Regulations and must be examined periodically by a boiler inspector. The maximum interval between examinations for most type of boilers are 14 months. Some other boilers, such as utility boilers less than 21 years since first use, may have to be examined within 26 months. The boiler owner should keep records of periodic examination for at least the recent three years.

1.6 Certificate of Fitness

1.6.1 Section 33 of the Ordinance prescribes the conditions for the issuance of Certificate of Fitness by a boiler inspector. If the boiler inspector is satisfied with the condition of the boiler, which he has examined, he should issue a Certificate of Fitness in a prescribed form and also deliver two copies of the certificate to the owner. The owner must then deliver the two copies of the certificate to the Authority within 7 days. The original Certificate of Fitness must be kept and displayed in a prominent place on the premises where the boiler is installed.

1.6.2 Section 49(1) of the Ordinance requires that boiler can only be operated when its Certificate of Fitness is still valid.

1.7 Prohibition Order

1.7.1 The Authority may issue a Prohibition Order to prohibit any further use of a boiler when it appears to him that -

(a) the boiler or its auxiliary equipment are not in safe working order;

(b) the boiler or its auxiliary equipment have not been examined in accordance with the Ordinance;

(c) the boiler is operated at a pressure higher than its maximum permissible working pressure; or

(d) the seal of the safety valve is broken or the setting of the safety valve has been tampered with by an unauthorized person.

1.7.2 Upon receiving the prohibition order, the owner and the operator must stop using the boiler immediately and rectify the faults for which the prohibition order is issued. The owner should engage a boiler inspector to thoroughly examine the boiler and issue a fresh Certificate of Fitness. This Certificate of Fitness should be produced to the Authority, who will permit the resumption of the use of the

boiler concerned.

1.8 Sale, Hire or Removal of Appliances

1.8.1 If a fossil-fuel boiler is hired or sold, the owner must notify the Authority within 7 days of the name and address of the person to whom it has been hired or sold, and must report whether the sale or hiring involves removal.

1.8.2 Any fossil-fuel boiler which has been removed either to new premises or to another part of the same premises must be examined by a boiler inspector before it is put into use again. The owner should also notify the Authority the new installation address.

1.8.3 The owner of a registered fossil-fuel boiler must notify the Authority within 7 days if he changes his address.

1.9 Examination after Extensive Repairs

1.9.1 If extensive repairs have been carried out to a boiler or to its auxiliary equipment, fittings and attachments, the boiler must be examined by a boiler inspector and issued with a Certificate of Fitness before being put back into use. Extensive repairs mean any repairs that affect or may affect the structure of the boiler and include alterations or welding repairs to the pressure parts of the boiler or its controls and safety devices.

1.10 Accidents and Defects

1.10.1 If an accident occurs to a boiler or its auxiliary equipment or if the owner becomes aware of any defect that is likely to endanger life or property, he must at once take the boiler out of use and notify the Authority of the accident or defect within 24 hours. A copy of the latest Certificate of Fitness must be sent to the Authority at the same time together with detailed information about the boiler and the accident or defect. (See Chapter 7 of this Code).

CHAPTER 2
ESSENTIALS OF FOSSIL-FUEL BOILERS

2.1 Basic Principle

2.1.1 Generation of steam in a closed vessel causes an increase in pressure due to a large increase in volume following a liquid-to- gas phase change. This process accompanies an increase in temperature of the water and the generated steam.

2.1.2 Design pressure is maintained while maintaining designed water level with a steam space above it, and controlling steam generation to balance steam flow from the boiler.

2.1.3 Water must be continuously supplied for the steam generation. For all input conditions, water pressure and temperature at inlet remain nearly fixed. The heat input to the boiler is through the combustion of fossil fuel - coal, oil or gaseous fuel.

2.2 Types of Boiler

The demand for steam for power generation as well as industrial processes is continuously increasing. Steam boilers now cover a wide range - from those required to run a laundry to the very large ones used in electric power generation. Some of the recent boilers installed in Hong Kong deliver approximately 2,000 tonnes of steam per hour. Steam pressures and temperatures can be as high as 19,360 kPa (2,800 psi) and 538ºC (1,000ºF) respectively.

In general, fossil-fuel boilers are of two main types:-

(a) The Fire-tube or Shell Boiler; and
(b) The Water-tube Boiler.

2.2.1 Fire-Tube boiler

Fire-tube boilers are potentially dangerous as the steam pressures are high and the volume of hot water and steam content is large. Features normally include:-

(a) water surrounds the tubes through which hot combustion gases pass before venting to atmosphere through gas uptakes.

(b) water converted into high pressure steam by transfer of heat from the very high temperature combustion gases.

(c) hot combustion gases produced by burning diesel oil, town gas etc. in the furnace.

(d) designed for automatic control.

Essential mountings include safety valves, pressure switches, pressure gauges, water level gauges, valve fittings, low- water level cut-off and alarm devices etc.

1. Smoke outlet
2. Stay bolt
3. Boiler Body
4. Furnace
5. Burner
6. Blow done exist
7. Fire tube
8. Reversing chamber (front side)
9. Flame detector
10. Pressure gauge
11. Manhole
12. Air blower
13. Feed water pump
14. Water gauge glass

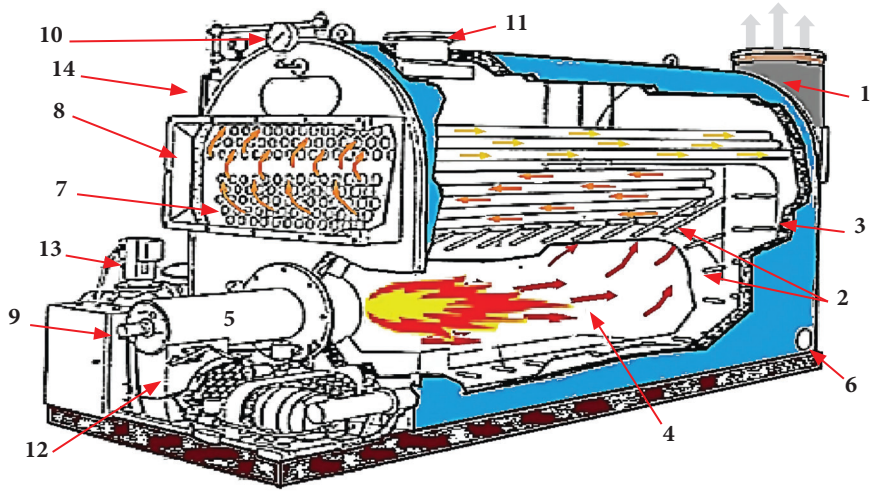


Figure 2.1: Fire-tube boiler

There have been various designs and constructions of the fire-tube boiler e.g. Vertical Cross Tube Boiler, Cochran Boiler, Vertical Dry Top Boiler, Scotch Marine Boiler, Horizontal Return Tube Boiler and Packaged Boilers. Packaged Boilers are completely self-contained units and are the latest development of the Scotch Marine Boiler. These boilers are factory assembled, tested and adjusted. Figure 2.1 illustrates one of these units. Each unit has electrically driven feed and fuel pumps, forced draught fan, combustion equipment, operating and safety control equipment for manual or automatic operation.

Figure 2.2 shows a typical feed water system commonly used for fire-tube boilers. These systems are also applicable to water-tube boilers with some variations or extra auxiliary equipment/fitting.

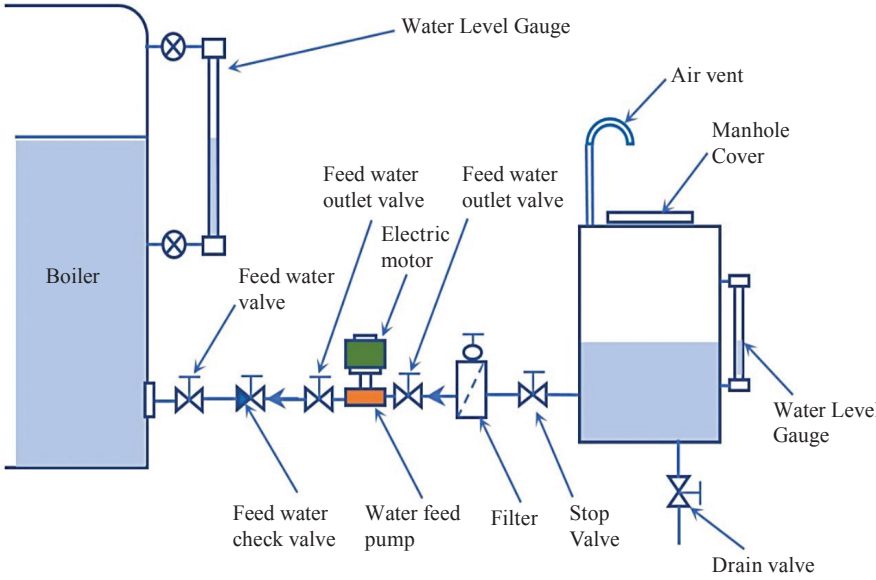


Figure 2.2: Feed water system of a boiler

2.2.2 Water-Tube Boiler

Water-tube boilers provide for better water circulation, more heating surface and reduced explosion hazard. A basic water-tube boiler is illustrated in Figure 2.3. Features normally include:-

a) hot combustion gases surround the tubes through which water/ steam circulates.

b) water is converted into high pressure steam, saturated or superheated, by transfer of heat from the very high temperature combustion gases.

c) hot combustion gases produced by burning coal, oil or gas in specially designed water cooled furnaces.

d) essential mountings include safety valves, feedwater controller, combustion control system, water level controller, pressure and temperature controllers, and low- water level alarm and cut-off devices etc.

The water-tube boilers have advanced considerably through development of a design connecting the steam generating tubes directly to a steam separating drum and featuring the use of bent tubes as against earlier straight tubes. Steam pressure and steam conditions also increase through adoption of steam reheating, regenerative feedwater heating and construction of larger boilers incorporating pulverized coal firing rather than the old fashion stokers that proved inadequate for modern highly forced boilers. The higher volumetric combustion rates and unit sizes of pulverized coal firing units has been achieved through the use of water cooled furnaces. This technique eliminates the problem of rapid deterioration of refractory walls due to slag, and reduces fouling of convection heating surfaces to manageable proportions by lowering the temperature of the gases leaving the furnace. Figure 2.3 illustrates a modern water-tube boiler.

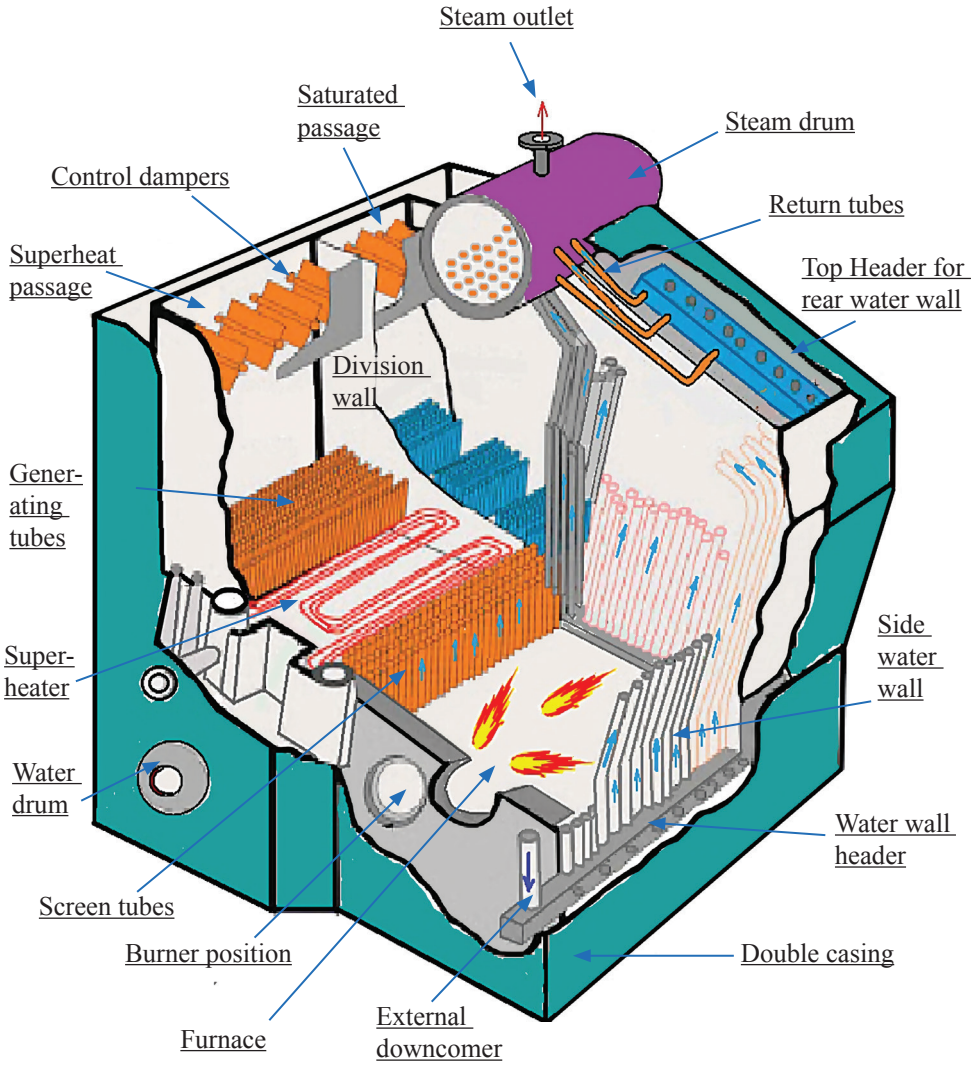


Figure 2.3: Water-tube boiler

2.3 Construction of Boiler

2.3.1 Welding

Fabrication of the pressure and non-pressure parts and the auxiliary equipment for modern units involves unique manufacturing methods and extensive use of diverse welding techniques. Welding is especially important in the construction of boiler drums and pressure parts. Its development has facilitated fabrication of pressure components of large size and great functional capability. All pressure part welding performed on power boilers and pressure components must be performed by "qualified welders" and "approved welding procedures". The welders are qualified by competent authority or by a recognized inspection body while the welding procedures are approved in accordance with a recognized code or standard. Adherence to approved procedures through employing qualified personnel is fundamental to safety and dependability. Another important means for ensuring quality of materials and fabrication is by means of non-destructive examinations e.g. radiography, ultrasonic, magnetic particles or dye penetrant. Figures 2.4 – 2.7 show different type of non-destructive examinations

Figure 2.4:
Radiography examination

Figure 2.5:
Ultrasonic examination

Figure 2.6:
Magnetic particle examination

Figure 2.7:
Dye penetrant examination

2.3.2 Fuel Burning Installation

The fuel burning installation consists of an air blower, a burner and fuel supply as shown in Figure 2.8. The air blower supplies air for combustion and purging before and after any combustion. The burner atomizes the oil fuel for ease of ignition and good combustion. The burner, or more exactly nozzle, in a gas fired boiler does not atomize the gas but provides a cone of flame of the designed length and angle for optimum combustion.

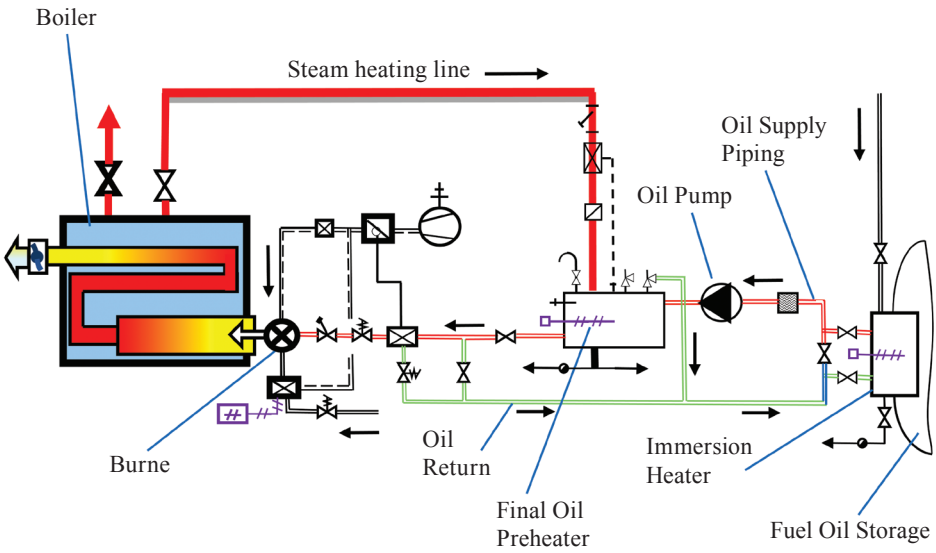


Figure 2.8 : Fuel burning installation

2.3.3 Fittings

2.3.3.1 Safety Valve

Every fossil-fuel boiler must have a spring loaded safety valve attached directly to the boiler separate from any stop valve and capable of being sealed. The safety valve automatically prevents the boiler from being operated in excess of its maximum permissible working pressure and can give a visual/audible alarm to the operator should other alarm and automation systems fail. The capacity of the safety valve must be such as to be capable of discharging maximum boiler output with the stop valves shut and without causing any excessive increase in steam pressure. Permanent provision must be made for the hot effluent from the safety valve to be discharged safely when it blows. Figure 2.9 shows a typical safety valve suitable for a fossil-fuel boiler.

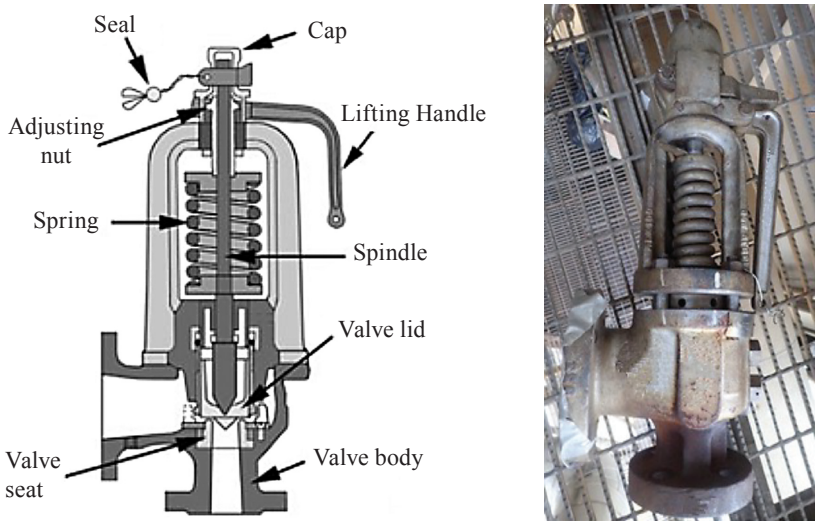


Figure 2.9: Safety valve

2.3.3.2 Water Level Gauge

Every fossil-fuel boiler must be fitted with at least one water level gauge of transparent material. Figure 2.10 shows a typical water level gauge glass. It allows constant visual observation of the water level in the boiler. In the case of glass tubular types, an efficient guard, for protection of persons from injury by a burst glass gauge, shall be provided.

Figure 2.10: Water level gauge

2.3.3.3Low Water Level Alarm

This alarm shall give visual and/or audible warning signal in the event of low water level in the boiler. The level at which the alarm is activated shall follow instruction by the maker or as advised by the boiler inspector.

2.3.3.4 Stop Valve

Every fossil-fuel boiler must be fitted with a suitable stop valve. Figure 2.11 shows a stop valve which is normally found in a steam system used to allow flow of a steam from the boiler.

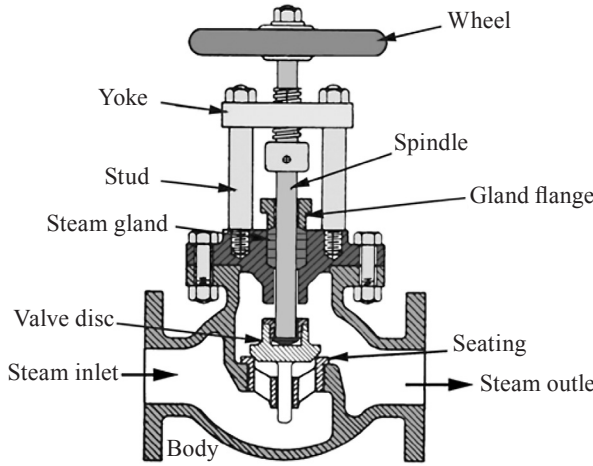


Figure 2.11: Stop valve

2.3.3.5 Steam Pressure Gauge

Pressure gauge connected to steam boiler should be marked on it by a red line indicating the maximum permissible working pressure (MPWP) of the boiler. The gauge should be calibrated and marked with suitable range to indicate the pressure of steam in the boiler in pascals or multiples of pascals.

Means for attaching a test pressure gauge shall be provided for each boiler. Figure 2.12 shows a pressure gauge suitable for a boiler.

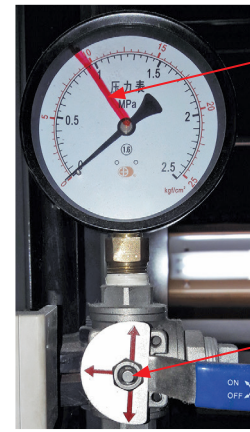


Figure 2.12: Pressure gauge

2.3.3.6 Miscellaneous

Air vent - should be fitted at the highest point of the boiler to release air trapped inside the boiler during flashup or to prevent creation of vacuum during shutdown; and

Bottom blowdown or drain - should be fitted for blowdown during operation to remove precipitates or to empty the boiler for layup or maintenance work to be carried out. Hot effluent from the blowdown should be discharged safely.

2.3.4 Boiler Control

In manual control of a boiler, the operator must maintain a tedious constant watch for the occurrence of any disturbance. Time is required for the boiler to respond to a correction, and this can lead to possible over-correction with further disturbance to the boiler. However, an automatic controller does not experience tedium and, once properly adjusted, will always make appropriate adjustments to minimise disturbances to the boiler and, therefore, will generally control the system more accurately and reliably.

Boiler control regulates the outlet conditions of steam flow, pressure, and temperature to their desired values. The quantities of fuel, air and water are adjusted to obtain the desired outlet steam conditions. The control system has the function of "looking at" the desired and actual values of the steam conditions and adjusting the amounts of fuel, air and water to make the outlet conditions match their desired values. The controller can be manual with the operator making the adjustments or it can be automatic using a pneumatic or computerised system.

2.3.5 Automatic Controls

Instruments and controls serve to assure safe, economic and reliable operation of the equipment. Boiler control systems for fossil-fuel boilers include:-

(a) boiler instrumentation.

(b) combustion control.

(c) steam temperature control.

(d) water level control.

(e) burner-sequence-control.

2.3.6 Instrumentation System

Instruments and methods for measuring pressure, temperature, flow and the quality and purity of steam are essential in the operation of a boiler. They range from the simplest manual devices to the more complex measuring devices used to actuate the automatic control of boilers and their auxiliaries.

The use of a pressure gauge for determining steam drum pressure is a statutory requirement. It has to be easily readable, calibrated in pascals or multiples of pascals, and have the approved maximum permissible working pressure clearly marked in red.

In steam boiler practice, it is frequently desirable to know accurately the metal temperature of tubes in e.g. furnace walls, economizers, superheaters, etc. Such measurements may be for determining safety of pressure parts or other causes and the use of thermocouples is a very practical and reliable method of temperature measurement, which is used extensively. Thermocouples are particularly well suited for the measurement of temperature at interfaces between successive layers of insulation or at other points inside the insulation.

Steam purity or quality, which depends on the application and is of particular importance to high pressure boilers, can be tested on steam, condensate or boiler water using some or all of following methods:-

(a) Sodium tracer (flame photometry).

(b) Electrical conductivity (for dissolved solids).

(c) Throttling calorimeter (for quality).

(d) Gravimetric method (for total solids).

The facilities available at site should be checked and the relevant instructions for the use of the equipment strictly complied with.

2.3.7 Automatic Sequence Control

This control permits start-up of burner equipment from a single push button or switch control. Burner control systems of various types are now applied to almost all boilers to prevent continued operation of a boiler where a hazardous furnace condition could exist and to assist the boiler operator in starting and stopping of burners and fuel equipment. The most important burner-control function is to prevent a furnace or pulverizer explosion, which could threaten the safety of operating personnel and possibly damage the boiler. The capabilities of burner-control systems must be clearly understood by all personnel connected with the boiler operation.

2.3.8 Flame Detection

A burner-control system must incorporate means of assuring the presence or absence of flame on each individual burner regardless of the type of fuel being burned. Ultraviolet (UV) flame detectors have been successfully applied for all types of fuels. Flame monitoring devices in current use are designed for on-off type of operation based on the presence or absence of the flame. Some plants today are using closed-circuit television to provide a means of continuous furnace observation by the control room, and more applications are expected in future.

CHAPTER 3
OPERATION OF FOSSIL-FUEL BOILERS

3.1 General

The safety and dependability of boilers and their auxiliary equipment requires that they receive proper attention not only while they were being designed, manufactured and erected, but also, of equal importance, while they are in service.

Good operation begins before equipment installation is complete. It includes the training of the operators as well as preparation for the startup of the equipment.

The ideal time to become familiar with new equipment is during the pre-operational phase when the equipment is being installed and commissioned and when the boiler has been shut down and opened for periodic examination. All preliminary operations for testing fans, pumps, fuel burning equipment, or for cleaning, drying, boiling out and blowing steam lines should be performed by experienced operators, working under the supervision of an appointed boiler inspector or a person authorized/approved by the Authority. Such personnel have the knowledge and experience to ensure the safe operation of equipment by correct adjustments of controls, interlocks, fuel burning equipment and operating procedures.

All operational data during the running and operational period of a fossil-fuel boiler should be recorded for reference. These record books should be kept by a responsible person for as long as practicable, otherwise be kept for at least the recent 3 years or, for a boiler used for less than 3 years, since registration and put to use.

3.2 Preparation for Startup

All preliminary operations for testing, cleaning and blowing steam lines of the boiler should be performed by experienced competent persons, working under the supervision of a boiler inspector or person

authorized by the Authority. They should have the knowledge and experience to ensure the safe operation of boiler by correct adjustment of controls, interlocks and cutouts.

Every new boiler or any boiler that has undergone major repairs or alterations must be prepared for putting back into service through various steps, such as inspection, hydrostatic testing and safety valve setting and testing.

3.3 Inspection

An inspection of the boiler and auxiliary equipment serves two purposes:-

(a) it verifies the conditions of the equipment, and

(b) it familiarizes the operator with the equipment.

The inspection should begin sometime during the construction or periodic examination phase and continue until all items are completed. One item which shall not be overlooked during inspection is the provision for expansion of steam lines, flues and ducts, soot blower piping, and drain piping. Temporary braces, hangers or ties used during construction or examination must be removed.

3.4 Cleaning

Debris and foreign material which accumulate during shipment, erection, or repair should be removed. Debris on the waterside can restrict circulation or block drain lines. Debris on the gas side can alter gas or air flows. Combustible material on the gas side can ignite and burn at uncontrollable rates and cause considerable damage. Glowing embers can be the source of ignition at times when ignition is not desired. Fuel lines should be cleaned to prevent subsequent damage to valves and the blocking of burner parts. Atomising steam and atomising air lines should be cleaned.

3.5 Startup from Cold

3.5.1 The following procedures should be followed when starting a fossil-fuel boiler from cold condition:-

(a) Read and be fully conversant with the detailed operating instruction for the boiler and its auxiliaries.

(b) Check the Certificate of Fitness (CF) for the boiler to ensure that it has not expired and that the approved maximum permissible working pressure (MPWP) is indicated on the pressure gauge by a red line.

(c) Shut the steam outlet stop valve and the blow down/drain valve.

(d) Open the air vent.

(e) Set the water level gauge valves/cocks to the normal operating positions (see Appendix II for reference).

(f) Feed water into the boiler as appropriate until the water level is just below the half-gauge level.

(g) Check that the fuel supply is securely connected and there is no visual loose connection or fuel leakage.

(h) If the fuel is in the form of gas supply, the installation of gas pipe line should be constructed by registered worker in Electrical and Mechanical Services Department.

(i) Set the heating at low firing rate.

(j) Switch on the blower to purge the furnace for the period recommended by the maker or for at least 15 minutes. The operator should observe the uptake flap to ensure that a draught for purging has been established in the furnace. If such flap is not provided, the operator should make use of the particular boiler design to ensure that draught has been established.

(k) Switch on the oil fuel pump or the main gas supply and see that fuel pressure is built up and the oil fuel is circulating (no circulation is necessary for gas fuel). Confirm that there is no fuel leakage. If there is any leakage, shut down the boiler and arrange the repair before proceeding.

(l) Now the boiler ignition system may be switched on to establish a flame inside the furnace, for raising steam at a low firing rate. The operator may choose to a use continuous firing method or intermittent firing method depending on the design and the past operating experience of the boiler. Intermittent firing is safer but takes a longer time to raise steam. In many practices, intermittent firing is typically 10 minutes fire in every 20 minutes, until steam is generated.

(m) If the ignition fails, repeat from step (g). However, if it fails to ignite for several times, stop the fuel supply and purge the furnace for the period recommended by the maker or for at least 10 minutes. Examine the burner, the flame detector and the fuel system such as fuel quality (e.g. is there water contamination in the oil fuel). When everything is found in order, repeat from step (g).

(n) The boiler should be heated gradually to raise steam. After steam has been coming out from the air vent for 3-5 minutes, shut the air vent. This waiting period is to ensure that all air trapped inside the boiler has been driven out.

(o) The boiler may now be switched to high firing rate to bring the steam pressure to the working pressure which shall be less than the MPWP.

(p) Blow the water level gauge (see Appendix II for blowing procedures) to see that the gauge is in proper working order.

(q) When the steam pressure has reached the working pressure, open the steam outlet stop valve gradually and cautiously. If hammering or any abnormal noise is heard along the steam

pipeline, do not open the stop valve any further. Instead, the stop valve should be closed to a 'cracked open' position (about 1/2 turn open) to warm the pipeline. If possible, the pipeline should be drained during this procedure. After warming the pipeline for a few minutes, the stop valve can be opened gradually and cautiously again until fully opened.

(r) The steam outlet stop valve should be fully open at all times during operation. Do not throttle the stop valve.

3.6 Duties of Competent Person

3.6.1 Boiler steam pressure must be maintained within close limits of the working pressure. For a manual boiler, it is done by adjusting the firing rate. For an automatic boiler, the operator should see that the fire is automatically switched ON or OFF at the prescribed pressure. In no case shall the MPWP be exceeded.

3.6.2 Boiler water level must be properly maintained. For a manual boiler, water is fed into the boiler from time to time to maintain the level at about half-gauge. Too high or too low a water level must be avoided. For an automatic boiler, the operator shall see that water is being fed into the boiler automatically at prescribed levels.

3.6.3 The operator should ensure a good reserve or a reliable water supply. The boiler must be shutdown in case of interruption in water supply.

3.6.4 The water level gauge must be under continuous observation. When a low water level alarm or, in the case of automatic boiler, a low water level cut-off is fitted, the operator must never rely solely on these devices. It may be too late if the operator takes action only when such alarm devices are activated, not to mention if they are not functioning. The water level gauge should be tested by blowing through the cocks at least once in a watch. Appendix II contains the correct procedures for blowing a water level gauge.

3.6.5 The safety valve is an important safety device to prevent the boiler operating at an excess pressure and causing explosion. The safety valve can get jammed or stuck at times and should therefore be lifted

to blow periodically by the easing gear, if fitted. This will ensure that it remains free to operate.

3.6.6 The low water level alarm and the extra-low level cut-off device as shown in Figure 3.1 should be tested periodically to ensure that it is functioning. This test can be done, while the boiler is firing and before it takes up the normal load, as follows:-

(a) switch off the feed water supply;

(b) isolate the water level float chamber and open its drain to lower the water level inside it;

(c) the alarm should operate and the cut-off device, if fitted, should switch off the fire;

(d) if the devices do not work at the prescribed water level, the boiler is to be shut down and the devices to be repaired or adjusted; and

(e) when the devices have been functioning properly, bring the float chamber to normal, switch on the feed water supply and reset the boiler to resume normal operation.

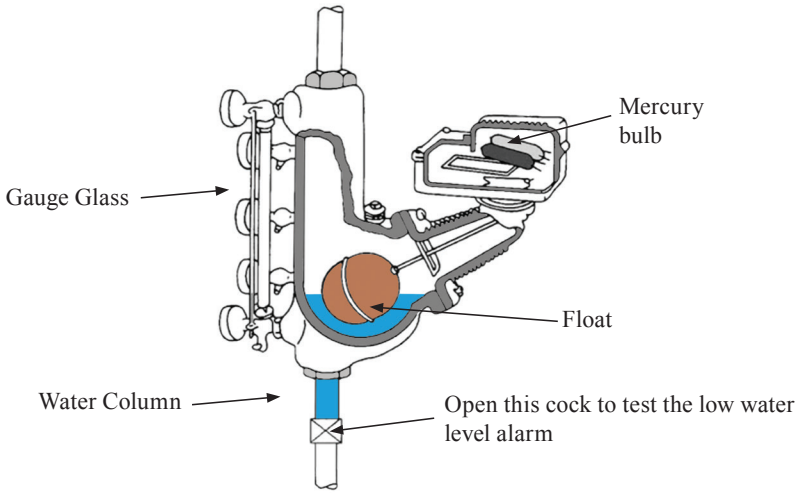


Figure 3.1: Low water level sensor

3.7 Water Treatment

3.7.1 The competent person must use the recommended sampling system or testing the boiler water quality. The correct dosage of water treatment chemicals should be used as recommended by the boiler manufacturer or the supplier of the chemicals for the boiler water treatment.

3.7.2 The limits generally recommended for low pressure boilers of usual operating pressure in the range between 0-15 bar are:

Alkalinity to Phenolphthalein	50-300 ppm $CaCO_3$
Chloride max.	300 ppm $CaCO_3$
Phosphate	30-70 ppm $CaCO_3$
Dissolved solids max.	1500 ppm

3.7.3 Boiler water and condensate should be regularly tested using appropriate testing kit and following appropriate testing instructions and procedures in accordance with maker's or chemical supplier's recommendation. The test result records should be kept by a responsible person for as long as practicable for reference, otherwise be kept for at least the recent 3 years or, for a boiler used for less than 3 years, since registration and put to use.

3.7.4 The competent person must exercise extreme care when handling chemicals for boiler water treatment since most of them are corrosive and/or poisonous.

3.8 Fuel Burning Installation

3.8.1 The operator must ensure that there is no fuel leakage. Oil fuel leakage is detected easily. For gas fired installation, the operator should examine the joints for any gas leakage by applying soap solution to the joints. The bubbles formed indicate gas leakage. Portable gas leakage detector of appropriate type should be used as far as practicable.

3.8.2 Fuel burner, filters and oil fuel pumps must be kept free of leakage and the detector, if fitted, should be cleaned periodically to avoid possible false alarms and false cut-off.

3.9 Shutdown

3.9.1 The following procedures should be followed in a normal shutdown operation:-

(a) Switch off the oil fuel pump or the main gas supply and isolate the fuel supply.

(b) Purge the furnace to drive away any residual combustible vapour or gas.

(c) Shut the steam outlet stop-valve.

(d) Stop the feed water supply and shut off the feed water valves.

(e) Let the boiler cool down slowly. The operator should not drain all the hot water inside the boiler or feed in cold water in order to accelerate cooling as undue thermal stress is created.

(f) When the boiler pressure has dropped to about 20 kPa on cooling, open the air vent carefully. It will prevent vacuum being created when steam inside the boiler condenses.

(g) The water remaining in the boiler may then be drained and filled with nitrogen for preservation if the boiler is to be laid up for a considerable long time, say a few weeks. Care must be taken to discharge the hot water safely.

CHAPTER 4
EMERGENCIES

4.1 General

Some common emergencies are discussed here. The most appropriate action is through correct appreciation of the situation and using operator's knowledge of the boiler installation and its environment.

4.2 Electric Shock

4.2.1 Electric shock victims may be treated as follows:-

(a) **DO NOT** touch the victim;

(b) switch off the main power supply immediately;

(c) use an insulator e.g. dry plastic rod or dry stick, to remove victim's contact with the electrical live part. A pair of gloves suitable for electric work should be readily available for such an emergency;

(d) make the victim lie in a comfortable position;

(e) dial emergency service hotline 999;

(f) loosen the victim's clothing to ease breathing;

(g) cover the victim with blanket to keep him warm;

(h) if the victim shows any sign to vomit, help him to do so and clean him afterwards;

(i) it is not advisable to give the victim any kind of medicine but wait for the medical aid.

4.2.2 Shut down the boiler and report the incident to the Boilers and Pressure Vessels Division of Labour Department. The boiler must not be put into use again until instructed by the Authority.

4.3 Flame Failure

4.3.1 Any abnormal flame failure shall be dealt with as follows:-

(a) Never try to re-ignite the flame using the furnace heat and injecting fuel into the furnace.

(b) Purge the furnace for the period recommended by the maker or for at least 5 minutes.

(c) Switch on the flame ignition system.

(d) If the flame fails to establish, repeat from step (b).

(e) On repeated failure to re-ignite the flame, secure the fuel burning installation and, if necessary, stop the boiler for inspection.

(f) Examine the burner, the flame detector and the fuel supply for fuel quality, etc. When everything is found in order, start from step (b) to ignite the flame.

4.4 Low Water Level and Extra-Low Water Level

4.4.1 Whenever low water level or extra-low water level is observed, switch off the power supply and cut off the fuel to the boiler immediately. Shut off the steam outlet stop valve and allow the boiler to cool. **DO NOT** immediately feed water into the boiler to restore water level. The cold water fed in may cause damage to the hot boiler or even an explosion. Never rely solely on the low water level alarm or the extra-low water level trip. Blow the water level gauge to confirm the water level. If the level observed was faulty and the

true level is normal, bring the boiler back to operation carefully. Otherwise, shut down the boiler and inspect the boiler internally for any damage. Check the feed water system and repair as appropriate. Start up the boiler only after a satisfactory thorough examination of the boiler. If in doubt, call a boiler inspector to inspect the boiler.

4.5 Excess Pressure

4.5.1 Boiler steam pressure must never exceed the approved maximum permissible working pressure. If such a situation occurs, switch off the fire immediately. If the safety valve has failed to blow automatically, lift the safety valve by means of the easing gear, if fitted, to release the pressure inside the boiler. Shut off the steam outlet stop valve as appropriate to prevent damage to the system by the excessive pressure.

In the situation where the safety valve fails to function automatically, the boiler shall not be brought back to service again unless:

(a) the defect causing excessive pressure in the boiler is identified and rectified;

(b) the boiler shows no signs of leakage, structural damage or distortion;

(c) the system has been thoroughly checked; and

(d) the safety valve has been tested and reset correctly by a boiler inspector and a new Certificate of Fitness issued.

4.5.2 The safety valve prevents the boiler from generating excess pressure. The operator must not rely solely on the safety valve but must observe the steam pressure continuously and take corrective action as necessary.

4.6 Power Failure

4.6.1 In case the power supply to an individual boiler fails, the boiler must be shut down and a registered electrical worker called to trace the fault and repair the electric circuit. The operator shall not, unless he is also a registered electrical worker, attempt to repair the electric circuit.

4.6.2 The automatic control circuits should be checked from time to time by a duly authorized person to confirm that they are functioning correctly.

CHAPTER 5
MAINTENANCE

5.1 Preventive Maintenance of a Boiler

5.1.1 The capability of a boiler to operate safely is important and is best achieved through "preventive maintenance" procedures. Preventive maintenance includes a policy of operating a boiler installation properly and within its designed range. It includes maintaining the installation in a clean and good engineering condition. Preventive maintenance also provides for regularly scheduled shutdowns to make the statutory and other examinations which are not possible during operation, and to enable the carrying out of necessary repairs. Preventive maintenance is more cost effective when comparing possible alternative such as an unexpected breakdown or a serious accident.

(a) All maintenance and general repairs carried out on a fossil-fuel boiler should be recorded. These record books should be kept by a responsible person for as long as practicable for reference, otherwise be kept for at least the recent 3 years or, for a boiler used for less than 3 years, since registration and put to use.

(b) All modifications, extensive repairs and repairs involved with pressure parts other than those involved with part replacement, carried out on a fossil-fuel boiler should be recorded and reported. These record books and reports should be kept by a responsible person for as long as practicable since the equipment was registered and put to use.

5.2 In-service Maintenance

5.2.1 The first emphasis is on safe operation, the avoidance of conditions that could result in explosive mixtures of fuel in the furnace and the protection of pressure parts to prevent excessive thermal stresses or overheating, resulting in failure.

5.3 Furnace

5.3.1 The prevention of a furnace explosion should be accorded top priority because of the potential for personnel injury, the high cost of repairs and other adverse economic consequences. Four items are of major importance in the prevention of furnace explosions:-

(a) optimum operating procedures and OPERATOR TRAINING;

(b) optimum burner observation with prompt detection of flame failure;

(c) detection of unburnt combustibles in flue gases; and

(d) positive, immediate indication of the fuel-air relation at the burners.

5.3.2 It is imperative that procedures and basic principles for safe operation are clearly understood by the operators, even though fully automatic control may be used. The majority of furnace explosions result from failure to detect a loss of ignition, even though other indicators, such as dropping boiler pressure, steam temperature, exit- gas temperature, show that fuel is either not being burned or is being burned incompletely. This emphasizes the fact that nothing takes the place of seeing the fire.

5.3.3 A “combustibles alarm” to indicate the presence of unburned combustibles in the flue gas is considered as a good back up for flame observation. The differential air pressure, between burner windbox and furnace, is an essential aid in purging the furnace and igniting the flame, and ensuring normal operation. It is an excellent guide in the establishment of correct fuel-air relationship to prevent loss of ignition or the accumulation of unburned combustibles in and around the furnace.

5.4 Pressure Parts

5.4.1 A very important item of safety equipment is the boiler safety valve. Modern safety valves are highly dependable when properly installed, and their installation checked by a boiler inspector.

5.4.2 Next on the list of safety equipment is a reliable means to determine that the boiler is filled with water to the correct level. Monitoring of feed water and boiler water conditions, as well as steam purity, are essential for any boiler operation. Thermocouples installed in the furnace are an excellent guide to internal cleanliness of the boiler and can be used as an indicator of the need for chemical cleaning. Reliable measurement of metal temperatures, gas temperatures and temperatures of steam and water are necessary for safe operation and reasonable maintenance of the boiler installation.

5.5 Safety Valves

5.5.1 Safety valves on drum-type boilers are normally tested both for set point pressure and for the closing pressure. This requires that the boiler pressure be raised until the valve opens and relieves sufficient pressure for the valves to close.

5.5.2 The set point on each safety valve is normally checked, and adjusted if necessary, immediately after reaching full operating pressure. Safety valve seats are susceptible to damage from wet steam or grit. Cleaning of the boiler and blowing out the superheater and steam lines before testing safety valves is necessary.

5.5.3 High pressure safety valves are tested without permitting them to open fully by:-

(a) using special gags to restrict valve lift and to close the valve as soon as it starts to simmer; and

(b) using special calibrated hydraulic jacks or air operated motors to open the valves while the boiler is operating at normal

temperature and pressure. The popping pressure is determined by adding the effective jack pressure to the boiler pressure.

5.5.4 Testing of safety valves always requires caution. Safety valve exhaust piping and vent piping should not exert any excessive forces on the safety valve. High pressure safety valves cannot seal if they have damaged seats.

5.6 Hydrostatic Test

5.6.1 After the pressure parts are assembled but before the refractory and casing are installed, a hydrostatic test at 1-1/2 times the boiler approved maximum permissible working pressure should be applied to all new boilers and maintained for a sufficient time for the detection of any leaks. Gags should be used to prevent safety valve opening during this test even when the valves are equipped with the special internal plugs often supplied with high pressure welded valves. Blanks should be often installed in flanged valves.

5.6.2 High quality water should be used for the hydrostatic test to prevent internal fouling and corrosion. Demineralized water or condensate treated with 10 ppm of ammonia for control of acidity/alkalinity (pH value) and 500 ppm of hydrazine for control of oxygen should be used for all non-drainable superheaters and reheaters. A clear, filtered water, on the other hand, is suitable for components that will be drained immediately after the hydrostatic test.

5.6.3 After the boiler is filled, hydrostatic pressure is applied usually by a pump made specially for testing purposes. While water is being pumped into the boiler and pressure gradually increased, continuous inspection should be made to observe any leakage conditions that might need repair or become dangerous. During hydrostatic testing, safety precautions must be observed and non-essential personnel kept from the test area.

5.6.4 Test pressure must be held long enough, at least one hour, to allow minute leaks to be observed. Following this holding period, pressure

should be retained for a further period of inspection. Following inspection of the unit, the water should be drained. The refractory, insulation and casing work are completed in areas left open for test inspection.

5.6.5 A final overall inspection should be made after completion of the above work and before operation. Externally all components of the boiler must be checked for explosion clearances e.g. at platforms and walkways constructed adjacent to external members that move with the unit. Obscure corners must be examined for any blocking or loose items. Remove any combustible materials to eliminate explosion hazard during initial firing. Clean all internal cavities of dirt. and check all tubes for alignment, particularly tubes which might interfere with soot-blower operation.

5.6.6 Temperature plays an important part in hydrostatic testing. First, the metal temperatures and, therefore, water temperature should be above the dew point temperature of the surrounding air to prevent the formation of condensate on the parts being tested. Condensate obscures and prevents the detection of small leaks. Second, the water temperature should be kept low enough so that pressure parts can be touched and close inspections made. It should not be so high that water escaping small leaks evaporates immediately or flashes to steam. Finally, no air should be trapped in the unit during the hydrostatic test. As the unit is being filled, each available vent should be open until water appears.

5.6.7 Any blanks, gags and plugs used during the hydrostatic test should be removed after the test has been completed. Gags used with or without the hydrostatic plugs should not be applied until 80 to 90% of the set point pressure is obtained. Conversely, the gags should be removed when the boiler pressure has been reduced to 80 to 90% of the set point pressure. This procedure protects the seating surfaces of the valve and prevents excessive pressure on the valve stem.

5.7 Periodic Examination

5.7.1 Every fossil-fuel boiler must be opened for statutory periodic examination before expiry of its Certificate of Fitness. The boiler should be cleaned, defects should be repaired and all valves should be stripped for inspection and overhauled. Safety valves, water level gauges, low water level alarm and other automatic control devices shall be tested in a test run in the presence of the boiler inspector prior to the issue of Certificate of Fitness. The operator or the owner should organize the overhaul work of the boiler for examination by the boiler inspector.

5.8 Waterside Scale

5.8.1 Water contains different kinds of dissolved salts. Some salts form hard scale. Chemical treatment can largely reduce formation of hard scale but it is difficult to totally eliminate those hard scale forming salts. Hard scale formed on the boiler interior surfaces and the heating element surface will not only reduce the heating efficiency but may also cause overheating of the boiler and choking of small diameter pipes/valves.

5.8.2 The operator should cause the boiler to be shut down periodically for cleaning of the scale. The period should be in accordance with the boiler manufacturer's recommendation or after six months of operation.

5.8.3 Scale formation can be minimized by adding chemicals into the feed water to turn the heavy scale salt into non-adhering sludge. The sludge is subsequently blown out. However, chemical methods may not prove to be cost effective in small capacity fossil-fuel boilers. The operator must exercise extreme care when chemicals are handled since most of them are either corrosive or toxic. The instructions by the chemical manufacturer must be strictly followed. The operator should use appropriate types of chemical, in accordance with the boiler manufacturer's instruction.

5.9 Chemical Cleaning

5.9.1 Waterside impurities can lead to boiler tube failures or to carry over of solids in the steam, resulting in superheater tube failure or turbine blade deposits. Oil, grease and paint will bake on boiler tubes and form heat transfer barriers, causing the tubes to overheat and fail. In natural circulation boilers, oil can cause foaming, resulting in carryover and a false indication of water level. Silica can also form heat transfer barriers and, at the higher saturation temperatures, will volatilize and carry over with the steam to form deposits on turbine blades.

5.9.2 To remove accumulations of oil, grease and paint, the natural circulation boiler is given a caustic and phosphate boil-out after the feedwater system has been given a phosphate flush. This boiling out and/or flushing should be accomplished before operation. After boiling out and flushing are completed, products of corrosion still remain in the feedwater system and boiler in the form of iron oxide and millscale. It is recommended that acid cleaning for the removal of this millscale and iron oxide be delayed until operations at fairly high capacities have carried all loose scale and oxides from feedwater system to the boiler and results in a cleaner boiler.

5.10 Water Side Corrosion

5.10.1 Corrosion includes, for the purpose of this code, rusting, localized pitting and erosion of metal parts of the boiler. Corrosion causes wastage of metal which will weaken structural parts of the boiler rendering it liable to structural failure.

5.10.2 Removing scale is a good means to minimize corrosion. The operator should take the opportunity of shutdown to inspect the boiler for any serious corrosion, especially localized corrosion, during scale removal.

5.10.3 When serious corrosion is observed, the operator or the owner shall cause the boiler be inspected by a boiler inspector and be suitably repaired.

5.11 Fireside

5.11.1 Overheating of the furnace will cause change in the microstructure of the metal parts resulting in reduction of strength. The furnace or firetubes may deform and even collapse.

5.11.2 The operator should ensure that the water level inside the boiler is always normal to avoid overheating. Also, the operator should adjust fuel pressure or even change for a more suitable burner in order to prevent the flame from impinging on any part of the furnace.

5.12 Gas Side Corrosion

5.12.1 Fuel invariably contains impurities which are corrosive. Gas fuel is less corrosive but oil fuel may contain sulphur which on combustion combines with oxygen producing sulphur dioxide and sulphur trioxide. Both sulphur oxides form acid with water vapour. Acid is extremely corrosive to the metal part of the fireside.

5.12.2 The operator should ensure that the fuel used is not contaminated with water. Water contamination may not only extinguish the flame but also cause acid formation. The operator should use a low sulphur content fuel and maintain the exhaust flue gas temperature at boiler exit to the uptake above acid dew point, namely, 120ºC to prevent water vapour condensation inside the fireside.

5.13 Debris

5.13.1 Ash, soot and incombustible impurities can remain and deposit on the furnace and fuel gas passages. The problem is more aggravated with oil fuel. Such debris will not only impede heat transfer but also cause choking of the fuel gas passages. The efficiency of the boiler will be reduced. In serious cases, the boiler may be choked allowing accumulation of dangerous combustible vapour or gas as a result of poor purging.

5.13.2 The operator should periodically clean the fireside of any debris. He should always maintain the correct fuel to air ratio to prevent sooty smoke and to ensure complete combustion.

5.14 Salt Water Contamination of Oil Fuel

5.14.1 Salt water contamination of oil fuel has very serious consequence for the boiler. Besides reducing the combustion efficiency and extinguishing the flame, sodium salt in the salt water will form glassy slag on the furnace surface. In many cases, the sodium slag promotes high temperature formation of very corrosive vanadium compounds. The effect of the slag will not only reduce heat transfer or efficiency of the boiler but also corrode the metal surface at fire side.

5.14.2 The operator must remove water in the oil fuel. He should allow the oil fuel to settle in the storage tank, especially on a fresh charge of fuel, and to drain away the settled water at the bottom. If large amounts of water are found, the operator should stop using the fuel and check with the fuel supplier. The contaminated fuel must be removed and the storage tank be cleaned to remove any traces of water and salt that may exist. The drained oil/water mixture should be disposed properly and under no circumstances should the mixture be disposed into the public sewer.

CHAPTER 6
FIRE PRECAUTIONS, FIRE FIGHTING AND EQUIPMENT

6.1 Liquid Fuels

Liquid fuels evaporate at rates varying with the temperature. The more volatile fuels are those which give off vapour more readily at lower temperatures. With appropriate quantities of air, the vapour can form mixtures which will flash or explode if ignited. If ignition takes place inside a compartment, there will be an explosion with destructive results. The destructive ability of vapour mixtures can exceed that of many solid explosives; a cupful of gasoline has the potential explosive power of 2.26 kg (5 lb) of dynamite.

6.2 Precautions

6.2.1 Precautions relating to the storage of liquid fuel generally aim at achieving:-

(a) The elimination of either liquid or vapour accumulations outside the oil fuel tank or pipe system in use.

(b) The exclusion of all sources of ignition from the neighbourhood of any position where vapour-air mixtures may be in existence.

6.2.2 Air vent pipes to oil fuel tanks should be fitted with flame arresters consisting of double wire gauze of fine mesh. They must be kept clean, especially from paint, to allow them to fulfil their purpose. In the boiler room, no oil should be allowed to accumulate in the air boxes, furnace bottoms, or on the boiler room floor. If leakage from the oil fuel system to the boiler room occurs at any time, the oil supply to that part of the system should be shut off immediately. Oil- tight trays should be placed under all fittings from which liquid fuel may spill when the fitting is opened. Savealls should be frequently examined for the presence of oil. A box filled with sand should be kept in a readily accessible place in the boiler room to facilitate the extinguishing of any fire.

(a) Oily waste can ignite without any external application of heat (such as from a flame or spark), this is called spontaneous ignition. Oil waste should therefore be kept in a metal receptacle partially filled with water to prevent spontaneous ignition. The waste should be disposed of, as soon as possible.

(b) In general, the best safeguard against fire is a proper attitude towards cleanliness, the disposal of flammable refuse in all its forms, and an intelligent regard for possible danger. Many explosions have occurred when operating boilers merely because of lack of care and knowledge of potential danger.

6.3 Fire Fighting

6.3.1 In case of a fire in the boiler room, the competent boiler operator should:-

(a) Raise the alarm.

(b) Call the fire service.

(c) Restrict the air supply to the boiler room by closing windows and doors.

(d) Shut off the fuel supply to the burners.

(e) Attempt to put out the fire using fire extinguishers.

6.3.2 Oil fires - If water is used in fighting an oil fire, it should be sprayed on the oil using a special spray nozzle. Water has the effect of lowering the temperature of the oil below its fire point, and the fire will therefore go out. However, care should be taken not to allow too much water to accumulate, as oil being lighter than water will float on top of the water, and may cause what started as a small local fire to become a large general one. Foam is a better fire extinguishing agent to use in the case of oil fires and at least one 9 litres (2 gallons) foam extinguisher should normally be provided in each boiler room.

Foam floats on the surface of the oil and acts as a blanket thereby starving the fire of the oxygen necessary for combustion. Dry sand may be used as a means of confining the oil to a small area, thus preventing the oil from spreading. The oil fuel supply to the burners should be shut off, and for this purpose, a master shut-off valve is usually fitted in the oil fuel supply line and located outside the boiler room.

6.3.3 Electrical fires - In the case of electrical fires or fires in the close vicinity of electrical appliances, a fire extinguishing medium which is a non-conductor of electricity should be used, otherwise, the fire fighter may experience electric shock. Dry powder extinguishers and carbon dioxide (CO2) extinguishers are suitable for use on electrical fires. All fuses, switches, etc. that can isolate the affected section from the source of electrical supply should be withdrawn or opened.

6.4 Fire Fighting Equipment

Some commonly encountered types of portable fire extinguishers used in combating oil and electrical fires are described in the following paragraphs.

6.4.1 Foam Extinguishers

6.4.1.1 The original foam extinguishers consist of two parts, an inner container and an outer casing containing different chemicals. The outer casing is of lead-coated steel. The inner container is made of copper. The foam making contents are a solution of aluminium sulphate in the inner container and bicarbonate of soda in the outer container. The extinguisher is operated by merely turning it upside down. Other similar models may have double sealing valves which are released by a T-handle or level before the extinguisher is inverted.

6.4.1.2 Foam is emitted to a distance of from 6 m (20 ft) to 9.1 m (30 ft), and once started the extinguisher will empty and eject about 90 litres (20 gallons) of foam. The foam should be directed to fall upon the fire-if need be, by deflecting it from another surface. (Figures 6.1)

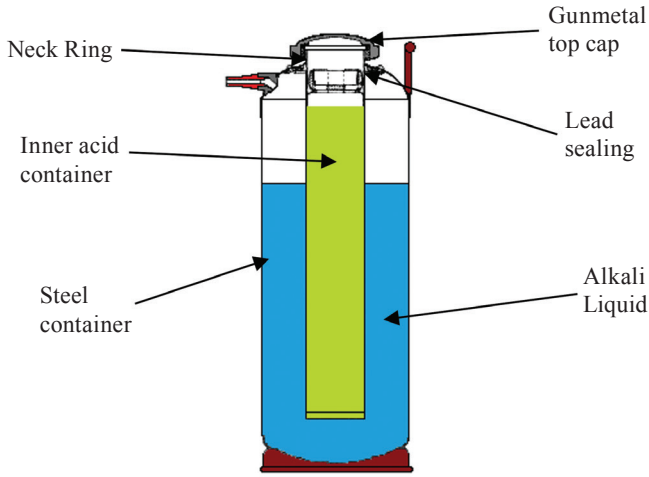


Figure 6.1: Portable Foam Extinguisher

6.4.1.3 An alternative type of mechanical foam extinguisher in Figure 6.2. The appliance is filled with water and contains an inner container with a small metal bottle of liquid carbon dioxide, surrounded by a plastic bag of foam making compound.

To operate this extinguisher it is necessary to strike the plunger on the cap sharply, thus piercing the seal of the CO_2 bottle. The gas then ruptures the plastic bag of foam compound and ejects the water and foam compound through a special nozzle which agitates the mixture and creates a mechanical foam. In this type of extinguisher the ratio of foam to liquid is about 8:1. The extinguisher has an internal pipe and is operated in the upright position.

6.4.1.4 Foam extinguishers are suitable for oil fires. They should not be used in fires involving electrical equipment as electric shock, which could prove fatal, might be experienced.

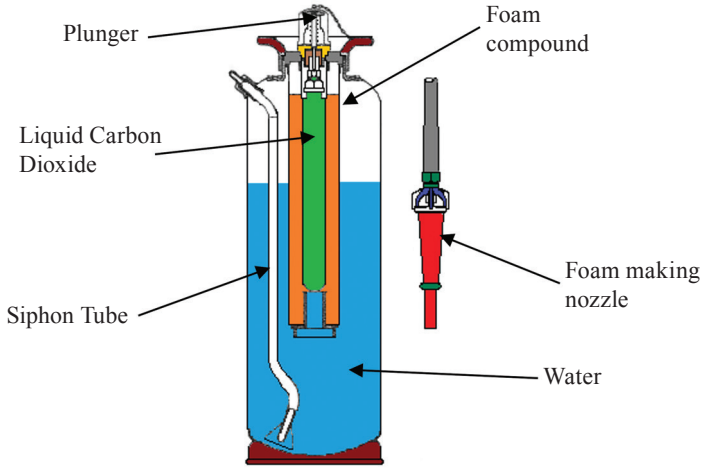


Figure 6.2: Mechanical Foam Extinguisher

6.4.2 Dry Powder Extinguishers

6.4.2.1 These extinguishers are suitable for oil fires as well as electrical fires. The extinguisher medium is finely processed bicarbonate of soda (dry powder), pressurized by CO_2 at a pressure of 21 kg/cm^2 (300 psi). The dry powder is a non-conductor of electricity, is non-corrosive, non- abrasive, and non-poisonous. The CO pressure charge may be checked by means of a flush-fitting pressure gauge fitted to the extinguisher body. There is also other type of dry powder extinguisher using compressed gas as expellant in a gas cartridge form. Figure 6.3 shows a typical dry powder fire extinguisher.

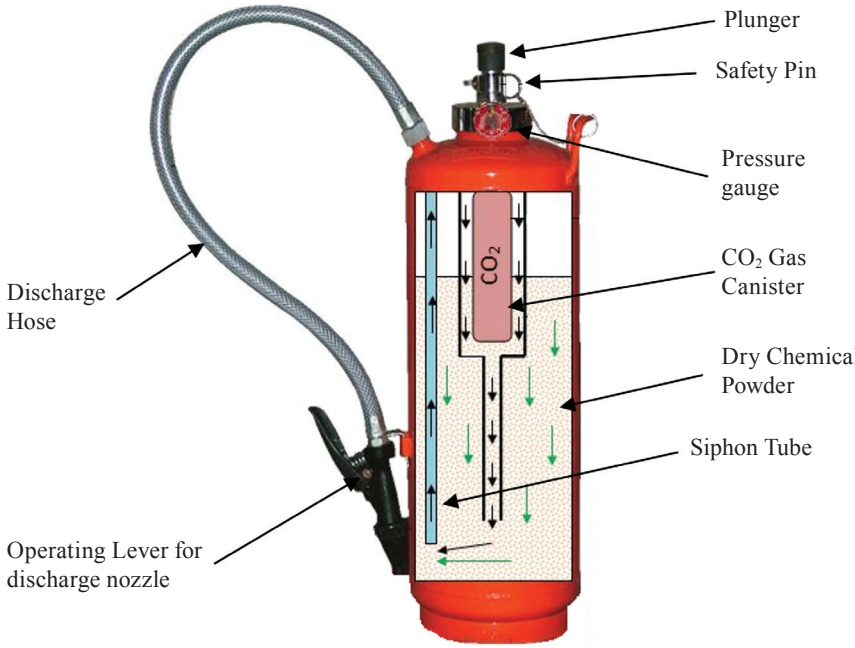


Figure 6.3: Chemical Powder Extinguisher

6.4.2.2 To operate the extinguisher, pull out the safety clip and strike the knob on top of the extinguisher. This causes a stainless steel piercer perforate a metal seal and release the contents. A horizontal fan shaped cloud of powder to be discharged, 7.62 m (25 ft) long, 1.82 m (6 ft) wide and 1.21 m (4 ft) deep. The duration of discharge is about 28 seconds and the discharge may be prolonged by interrupting the flow with the lever provided at the hose end.

6.4.3 Carbon Dioxide Extinguishers

6.4.3.1 The charge of CO_2 is controlled by a valve and lever so that part of the charge may be conserved if not fully used. Usually, the extinguisher contains 2.26 kg (5 lb) of CO_2 and the pressure inside the extinguisher body under normal temperature conditions is about 59.77 kg/cm^2 (850 psi). The period of discharge is about 8 seconds. Being sealed with a domed nickel diaphragm which requires piercing with the striker to discharge the contents, the extinguisher is virtually leak-proof. As carbon dioxide is a non-conductor of electricity these extinguishers may be used on fires involving electrical appliances. Figure 6.4 shows a CO_2 extinguisher.

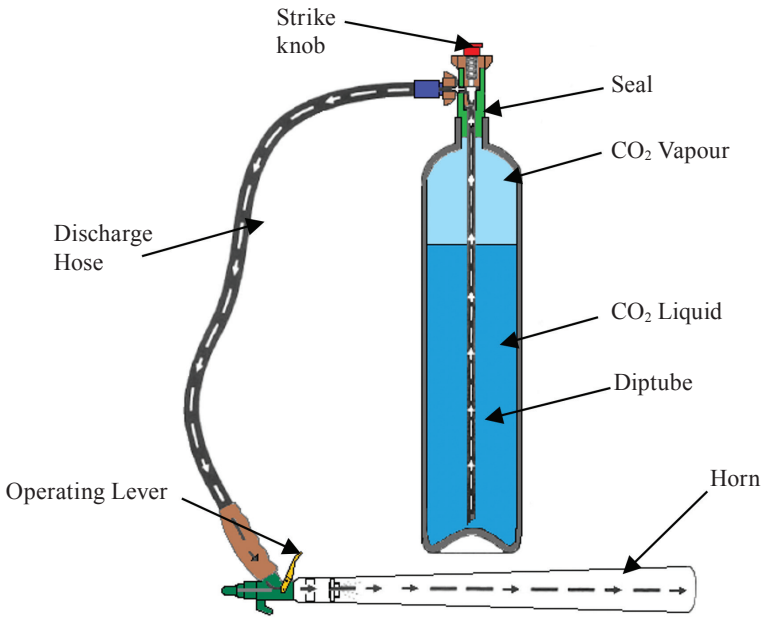


Figure 6.4: Carbon Dioxide Extinguisher

6.4.4 Colour Coding – Extinguishers

6.4.4.1 Fire extinguishers should have a red colour displayed body with identifying displayed in a wide band at top to designate the extinguishing medium should be as follows:-

Extinguishing medium	Colour to indicate extinguishing medium
Water	Red
Foam	Pale cream
Powder (all types except Class D)	Blue
Carbon Dioxide	Black
Wet chemical	Canary yellow

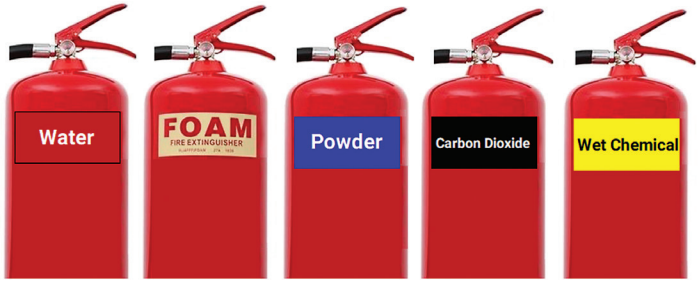


Figure 6.5 Fire extinguisher colours: the colour is displayed in a wide band at the top of the extinguisher

6.4.5 Uptake Fire

6.4.5.1 Soot and unburnt carbon can deposit on the walls of the boiler uptake (chimney). They form, in effect, another fuel and can catch fire in the uptake. Although uptake fires do not often occur, they can be very difficult to extinguish and the hazard builds up quietly and usually undetected. The fire is caused by smouldering of the deposits accumulated in the uptake. It usually occurs during boiler

shutdown or under light load condition. There is evidence that under normal loads the flue gas "cools" the soot and the carbon deposits so that a smouldering fire does not occur. In the absence of flue gas or if the flue gas flow is insufficient to cool the deposits, they can catch fire.

6.4.5.2 When an uptake fire occurs, it results in very high exhaust temperatures and excessive thick black smoke, mixed with sparks, coming out of the uptake. The boiler must be shut down immediately and the blower switched off or the damper closed to stop any air supply to the uptake. The fire service must be called. If the uptake is common for several boilers, all the boilers must be shut down. The key point is to stop the boiler air supply. No attempt should be made to extinguish the fire by water unless the water supply is plentiful. A steam fire may result if the water supply is not plentiful. The fire should be allowed to die out. The fire must be contained by restricting and removing any combustibles in the near vicinity.

6.4.5.3 To prevent an uptake fire, the operator must clean the uptake periodically to eliminate accumulation of soot and unburnt carbon. He should also exercise care in the daily operation of the boiler and maintain the correct air/fuel ratio to ensure complete combustion of fuel and minimize production of soot or unburnt carbon.

6.4.6 Provision of Fire Extinguishers

6.4.6.1 The owner must provide one set each of the following types of fire extinguishers near the entrance to the boiler room:-

(a) at least one 9 litres (2 gallons) foam extinguisher for oil fire; and

(b) at least one dry powder extinguisher or carbon dioxide extinguisher for electrical fire.

6.4.7 Fire Drill

6.4.7.1 The boiler operators and the workers working nearest to the boiler room and a supervisor should conduct fire drills at least once every

3 months. The drills should include:-

(a) the identification of the type of fire;

(b) the identification of the type of extinguishers to be used; and

(c) any other procedures to be followed.

6.4.7.2 A written procedure in case of fire should be posted outside the entrance to the boiler room.

6.4.7.3 A record book of fire drills with the dates, names and signatures of persons participating in the fire drill should be kept in the boiler room for inspection.

CHAPTER 7
ACCIDENTS AND DEFECTS

7.1 General

7.1.1 It is the responsibility of the owner of a boiler to report to the Authority when:-

(a) an accident occurs in or to the boiler or its auxiliary equipment; or

(b) he/she is aware of any defect in the boiler or in its auxiliary equipment that is likely to cause danger to life or damage to property.

7.1.2 The owner must forthwith stop the use and operation of the boiler and shall, as soon as practicable and in any event within 24 hours, notify the Authority of the accident or defect, as the case may be, and, where applicable, shall, at the same time, send to the Authority the latest Certificate of Fitness issued in respect of the boiler.

7.1.3 Every such notice shall include the following particulars:-

(a) the address or place at which the boiler is installed;

(b) a general description of the boiler;

(c) the purpose for which the boiler is or was used;

(d) where applicable, the name and address of the boiler inspector who issued the latest Certificate of Fitness in respect of the boiler;

(e) in the case of an accident in or to a boiler:

(i) the number of persons killed or injured, if any;

(ii) details of the part thereof that failed and the extent of failure generally, if known; and

(iii) the pressure at which the same was being operated at the time of the accident; and

(iv) in the case of a defect in a boiler, details of the nature of the defect.

N.B. It must be pointed out here that a safety valve with its seal broken, whatever is the cause, is considered a defect. Although such a defect does not create immediate danger, the owner must immediately arrange a boiler inspector to examine and re-seal the safety valve.

CLASSES OF CERTIFICATE OF COMPETENCY

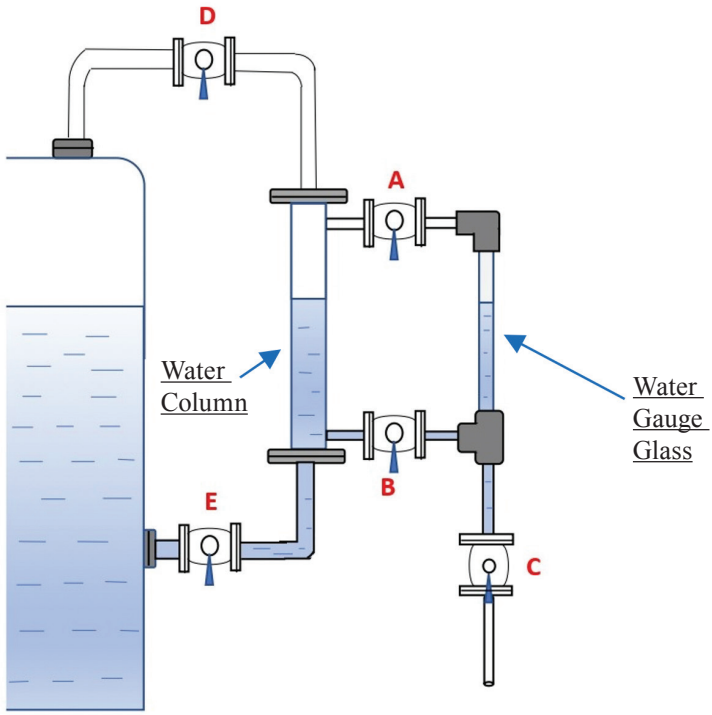
The following are examples of the types of equipment which the holders of different Certificates of Competency may operate:-

CERTIFICATE OF COMPETENCY	TYPE OF BOILERS/STEAM RECEIVER FOR WHICH THE CERTIFICATE IS VALID
A) All Classes (I to VI)	i) All Boilers (including automatically controlled with superheaters); and ii) Steam Receivers
B) Class I	i) All Water-tube Boilers (including automatically controlled with superheaters); and ii) Steam Receivers
C) Class I(A)	i) Water-tube Boiler (including automatically controlled but without superheaters); and ii) Steam Receivers
D) Class I(B)	i) Manually Controlled Water-tube Boilers (without superheaters); and ii) Steam Receivers
E) Class II	i) All Fire-tube Boilers (including automatically controlled); and ii) Steam Receivers
F) Class II(A)	i) Automatic Fire-tube Boilers; and ii) Steam Receivers

CERTIFICATE OF COMPETENCY		TYPE OF BOILERS/STEAM RECEIVER FOR WHICH THE CERTIFICATE IS VALID
G) Class II(B)	i)	Manually Controlled Fire-tube Boilers; and
	ii)	Steam Receivers
H) Class III	i)	All Electrically Heated Boilers (including automatically controlled); and
	ii)	Steam Receivers
I) Class III(A)	i)	Manually Controlled Electrically Heated Boilers
J) Class IV	i)	Sterilizing and Vulcanizing Boilers
K) Class V	i)	Special Purpose Boiler as specified
L) Class VI	i)	Steam Receivers

Certificates of Competency issued before the year 1981 namely, the B & S certificates, shall remain valid for the type of equipment as specified in the certificate. Any person who has any query about such certificates should consult the Boilers and Pressure Vessels Division.

BLOWING OF WATER LEVEL GAUGE



A Typical Water Level Gauge

It is a very common design to have all the FIVE cock handles pointing downwards while the water gauge is in use.

Procedure of blowing:-

When the boiler is in operation, the steam cocks A, D and water cocks B, E are open and drain cock C is shut.

(a) First shut both steam and water cocks A, D, B and E. Open drain cock C to prove that all the gauge cocks are in order. Then, with the drain cock C still open, cocks B and E should be opened. If water blows out freely from cock C, cocks B and E are clear.

(b) Shut off cocks B and E and open cocks A and D with the drain cock C still open. If steam blows out freely from cock C, cocks A and D are clear.

(c) To cross test, close cocks D and B, leaving E, A and C open. If water blows out from cock C, then E, A and the water-column are in order.

(d) Close cocks E and A, leaving D, B and C open. If steam blows out from cock C, then D, B and the water-column are in order.

When any of the cocks are found to be clogged, shutdown the boiler and overhaul the water level gauge.

Possible causes of gauge glass indicating incorrect level

(a) If cocks A and D or steam passage is shut or choked, boiler pressure will press the water level in the glass higher than the real water level of the boiler. The water level indication in glass will, therefore, be incorrect.

(b) If cocks B and E or water passage is shut or choked, steam will condense on upper column of glass and accumulate. The apparent water level shown can be higher than the actual water level, causing false reading.

Water gauge glass should be tested daily at *least* at every change of attendant. The safety of boiler operation relies greatly on proper functioning of the water gauge glass.

BASIC KNOWLEDGE OF COMBUSTION

Liquid fuel (e.g. diesel oil) and gaseous fuel are hydrocarbon fuels containing molecules made up of carbon and hydrogen atoms. Hydrocarbon molecules can be written as $C_m H_n$, where m and n are integer variables indicating the number of carbon atoms and hydrogen atoms building up the molecule respectively. Both carbon atoms and hydrogen atoms can react with oxygen chemically under high temperature. This chemical process is more commonly known as burning or combustion. Some impurities exist in the fuel and also undergo chemical changes during combustion. Harmful products may be produced depending on the type of impurities e.g. sulphur can form acidic oxide. However, impurities usually occupy a very minor part in the fuel. Careful operation can minimize or even eliminate the effect of harmful impurity products.

Hydrocarbon molecules combine with oxygen at high temperature to form carbon dioxide and water. At the same time a large amount of heat is generated. Part of this heat energy is in turn used to maintain the high temperature favourable for the combustion (chemical process) of the fuel, while most of this heat is extracted for use. In our subject of discussion on fossil-fuel boilers, bulk of the heat generated is used to raise temperature of the boiler water to form steam. Chemical Equation:-

$$\mathbf{C_m H_n + (m+n/4)O_2 = mCO_2 + (n/2)H_2 O + HEAT}$$

Air contains about 20% by volume of oxygen. It is a cheap and convenient source of oxygen for combustion. From the chemical equation, it can be seen that a certain minimum amount of oxygen, or air, is required for a particular hydrocarbon fuel to burn completely. Insufficient air supply causes poor combustion producing sooty smoke, less heat, carbon monoxide, etc. Taking into consideration air/fuel mixing efficiency and to ensure complete combustion, excess air is required. For most thermal oil heaters, 20-50% excess air is usually arranged. Excessive air will, however, lower the efficiency of the boiler, cause flame instability and create undesirably high flue gas temperatures. The correct amount of air depends on the fuel as m and n vary with the type

or supply of fuel. The operator should consult the fuel supplier and the burner appliance maker for the optimal air/fuel ratio. The operator should adjust the air blower damper mechanism as necessary to establish an optimal flame. An optimal flame is a stable flame (i.e. the shape of the flame is stable) with a near colourless exhaust.

The burner injects gas or atomizes oil fuel which mixes with the air from the blower. Turbulence produced by the air draught thoroughly mixes the fuel particles and air producing plenty of reacting contact surfaces between the hydrocarbon molecules and oxygen molecules. If a flame exists, the heat will cause the chemical process described above to occur and sustain the flame. If there is no flame but an ignition spark is produced, the high temperature spark (2000ºC or above) starts the combustion process and creates a flame. The combustion process is self-sustaining and the flame continue as long as there is fuel and sufficient air being supplied and mixed at the correct ratio.

Diesel oil vaporizes even at room temperature. The vapour is similar, in its effect, to gaseous fuel and is combustible. After a flame has been extinguished or a boiler has been shut down, residual diesel oil vaporizes and mixes with the air inside the furnace. This mixture is flammable and extremely dangerous. If any hot material is present it may set off a very rapid combustion with a large amount of heat released in an extremely short time or, more exactly, an explosion can occur. A spark for ignition purpose would be hot enough to cause such an explosion. This can happen if the operator tries to ignite a flame inside the furnace to start the boiler without knowing that there is an explosive mixture present. The spark can ignite the explosive mixture before igniting the fuel/air mixture to make the flame. A similar phenomenon applies in the case of gaseous fuel. The operator must take every precaution to eliminate accumulation of the explosive mixture. The rule is to purge the furnace every time before attempting to ignite a flame and to purge the furnace after extinguishing a flame. Never try to ignite a flame using the heat of the furnace. Under such circumstance, a large amount of fuel is injected into the furnace giving a very good opportunity for an explosive mixture to build up and to explode subsequently.

During ignition, the jet of fine fuel particles as atomized by the burner at high pressure or injected through gas nozzle mixes with air. This is a flammable mixture but got ignited and burnt before accumulating to large. However, if it fails to ignite a flame after several sparking, a considerable

volume of flammable mixture, which is explosive, may have created. The operator should not insist on attempting to ignite a flame. He should shut off the fuel supply, purge the furnace thoroughly to remove any explosive mixture which might have been created. He should check and eliminate any fault in the burning system. Most automatic combustion control fitted for automatic fossil-fuel boilers will carry out the above practice, except examining the system, automatically. Nevertheless, the operator should make himself aware of the consequence and should never be complacent. In case of failure of automatic device, the system shall be changed over to manual control where the operator has to exercise the above practice.

ALWAYS PURGE THE FURNACE BEFORE MAKING A FLAME!

BASIC KNOWLEDGE OF ELECTRICITY

Electric Circuit - a network of paths designed for electric current to carry out a specified function.

Circuit Breaker - one form of switch providing ON/OFF function and automatic tripping of the electric circuit in the event of short circuit or circuit overload. The point at which the breaker trips depends on the rating of the circuit. The breaker can be reset to operate again after the fault has been cleared.

Fuse - a conductor, usually in the form of a wire or a cartridge, of low melting point material placed in the electrical supply circuit and forms part of the circuit. It serves to protect the electric circuit from short circuiting or overloading. It melts to interrupt the electricity supply because the excess current produces a large amount of heat. Unlike the circuit breaker, it must be replaced with a new unit after blowing.

Earth Line - a conductor or wire which electrically connects the boiler metal casing with the earth terminal provided by the electricity supply company. This line plays a very vital role in the prevention of electric shock.

Electric Shock - this is a phenomenon whereby the human body has become a path for electric current. The human body may suffer burns and heart difficulties which can result in death.

When an electric wire of high potential becomes loose or exposed and is in contact with the metal casing of the boiler, the casing will also be at a high potential relative to the earth. If the earth line is also defective, the casing will be maintained at a high potential. There may not be any indication of the high potential but when a person is in contact with the casing and he is also in contact with the earth, an electric path for current is established through the human body. Potential differences above 50V, A.C. or D.C., are able to drive

electric current through the body. This is what is termed an electric shock. Alternating current has a more serious effect in that it can cause the victim to become paralysed while still holding firmly onto the faulty electric part. The normal mains supply in Hong Kong is nominally 220V A.C. which is well above the threshold voltage of 50V. However, it should be noted that, depending on the physical conditions of a person, potential difference less than this threshold voltage has been known to cause serious injuries.

IMPORTANT NOTE:- Never try to repair any faulty electric circuit. The repair should be carried out by a registered electrical worker only.

Occupational Safety and Health Branch
Labour Department

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